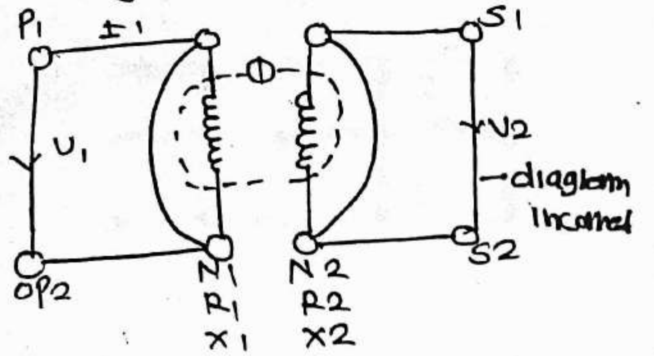
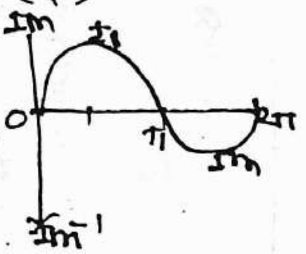
1) Drive the emf equation of single-Phase transformer

→



From figure mathematical equation of flux (Φ) given by

$\phi = \phi m \sin\omega t$



As we know that.

$\omega = 2\pi F$

$\therefore \phi = \phi m \sin 2\pi F t$

$e = -N \frac{d\phi}{dt}$ N - no. of turn coil, Φ - Rate of change flux

$e = -N \frac{d\phi}{dt}(\phi m \sin 2\pi F t)$

$e = -N\phi m \frac{d}{dt}(\sin 2\pi F t)$

$e = -N\phi m \cos(2\pi F t) \cdot 2\pi F.$

Now

$\cos(2\pi F t) = \pm 1$

$\therefore e_{max} = -N\phi m \, 2\pi F(\pm 1)$

$\therefore e_{max} = N\phi m \cdot 2\pi F$

$E_{Rms} = \frac{e_{max}}{\sqrt{2}} = 4.44 \cdot N \phi m F$

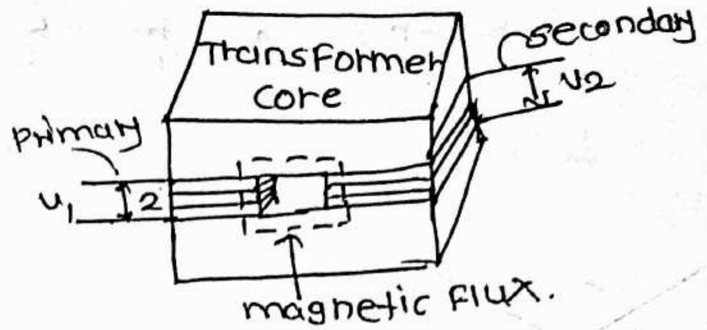
Primary induced emf

$E_1 = 4.44 N_1 \phi m f$

$E_2 = 4.44 N_2 \phi m f.$

Single Phase Tra

derive the expression for the transformer for delta connection



i) Turn ratio of transformation

$\boxed{\therefore \text{Turn ratio} = \frac{N_1}{N_2}}$

ii) Voltage ratio

$E_1 = 4.44 \phi m f N_1$ — (I)

$E_2 = 4.44 \phi m f N_2$ — (II)

Taking ratio (I) and (II)

$\frac{E_1}{E_2} = \frac{4.44 \phi m f N_1}{4.44 \phi m f N_2}$

$\boxed{\frac{E_1}{E_2} = \frac{N_1}{N_2}}$

iii) equation for voltage Ratio without load

$\therefore V_1 = E_1$

$\frac{E_1}{E_2} = \frac{N_1}{N_2}$

$\boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2}}$

$\therefore \text{voltage ratio} = \frac{V_1}{V_2} = \frac{N_1}{N_2}$

iv) transformation ratio (K)

$\boxed{\therefore K = \frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{V_2}{V_1}}$

v) Current ratio

$\boxed{\therefore V_1 I_1 = V_2 I_2}$

$\boxed{\therefore V_1 I_1 = V_2 I_2}$

$\therefore \frac{V_1 I_1}{I_2} = \frac{V_2}{V_1}$

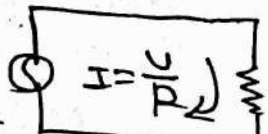
using this equation

$\boxed{\frac{I_1}{I_2} = \frac{V_2}{V_1} = \frac{N_2}{N} = K}$

Delta conection

Behaviour of a Pure resistance in AC circuit.

→ R circuit



current:-

Basic equation of I

$I=\frac{V}{R}$ $\frac{V_m \sin \omega t}{R}$

$I=\left(\frac{V_m}{R}\right)\sin \omega t$ —— (I)

standerd equation of current is $I=I_m \sin(\omega t+\phi)$ —— (II)

comparing (I) and (II)

$I_m=\frac{V_m}{R}$ & $\phi=0$

$\boxed{\therefore I=I_m \sin \omega t}$

Power:-

1) Instaneous Power (P)

$P=V\cdot I$

$V=V_m \sin \omega t$ and $I=I_m \sin \omega t$

$\therefore P=V_m \sin \omega t$ & $I_m \sin \omega t.$

$P=V_m I_m \sin 2\omega t$ —— (1)

$P=\frac{V_m I_m}{2}[1-\cos(2\omega t)]$

$\boxed{P=\frac{V_m I_m}{2}-\frac{V_m I_m}{2}\cos(2\omega t)}$

ii) average Power (Pav)

From equation No. 1

$P_{av}=\frac{V_m I_m}{2}$

$P_{av}=\frac{V_m}{\sqrt{2}}-\frac{I_m}{\sqrt{2}}$ —— $(\sqrt{2}.\sqrt{2}=2)$

$P_{av}=V_{rms}.I_{rms}$ —— watt.

Power:-

1) Active

$S=V_{rms}$ $\boxed{P=VI\cos\phi}$

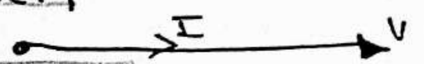
ii) Reactive

$\boxed{Q=VI\sin\phi}$

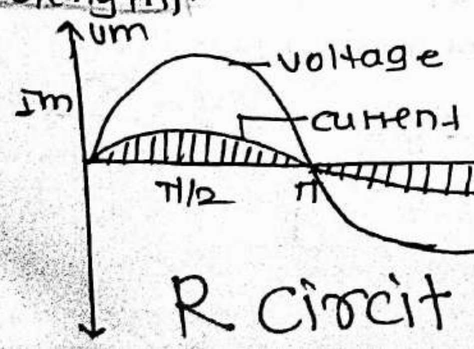
iii) Apperent

$\boxed{S=I_{rms}\,d\,I_{rms}}$

Phaser:-



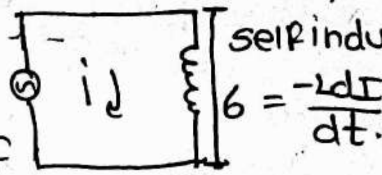
wavelength:-



R circit

Behaviour of Pure Inductor in AC circuit

→ L circuit



current.

self induced emf

$e=\frac{-LdI}{dt}$ supply of voltage is equal & opposite

$\therefore V=-e=-\left(-L\frac{dI}{dt}\right)=L\frac{dI}{dt}$

How $V=V_m \sin \omega t$

$\therefore V_m \sin \omega t$

$=L\frac{dI}{dt}$

$\therefore \frac{di}{dt}=\frac{V_m \sin \omega t}{L}$

$\therefore di=\frac{V_m}{L}\sin \omega t\, dt$

By integration

$i=\int di=\int \frac{V_m}{L}\sin \omega t\, dt$

use identity $\cos \omega t=\sin\left(\frac{\pi}{2}-\omega t\right)$

$\therefore i=\frac{V_m}{VL}\left[\sin\left(\frac{\pi}{2}-\omega t\right)\right]$

$\therefore \sin\left(\omega t-\frac{\pi}{2}\right)$

$\therefore i=\frac{V_m}{I_m}\left[\sin\left(\omega t-\frac{\pi}{2}\right)\right]$

$\boxed{\therefore i=I_m \sin\left(\omega t-\frac{\pi}{2}\right)}$

Power:- $P=V\times I$

we have $V=V_m \sin \omega t$ &

$i=I_m \sin\left(\omega-\frac{\pi}{2}\right)$

$\therefore P=V_m I_m \sin(\omega t).\sin\left(\omega t-\frac{\pi}{2}\right)$

$\therefore P=V_m I_m \frac{\sin(2\omega t)}{2}$

$\boxed{\therefore P=\frac{V_m I_m}{2}-\sin(2\omega t)}$

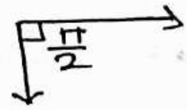
- Active, Reactive Power

1) Active:- $Q=VI\sin\phi$

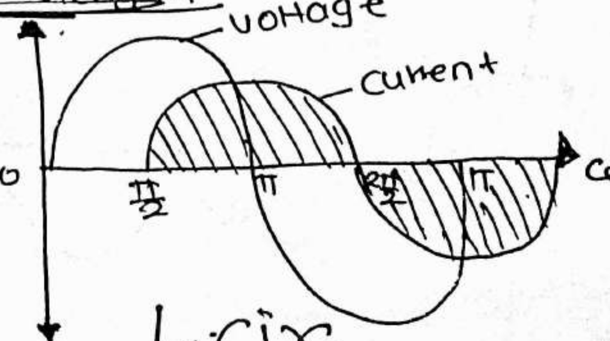
2) Reactive:- $P=VI\cos\phi$

3) Apparent:- $S=V\times I$

Phaser:-



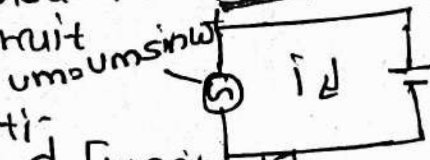
wavelength



L cir.

Behaviour like Pure capacitor.

→ C-circuit



current:-

$$i = \frac{dQ}{dt} = \frac{d}{dt}[V_m \sin\omega t]$$

$$= \left[V_m \frac{d}{dt}(\sin\omega t)\right]$$

$$\therefore i = (V_m \omega \cos\omega t) \quad \text{—①}$$

Rearranging eqn no —①

$$\boxed{\therefore i = \frac{V_m}{\frac{1}{\omega C}} \cos\omega t}$$

But $\cos\omega t = \sin(\omega t + \frac{\pi}{2})$

$$\therefore i = \frac{V_m}{\frac{1}{\omega C}} \sin(\omega t + \frac{\pi}{2})$$

$$\boxed{\therefore i = I_m \sin(\omega t + \frac{\pi}{2})}$$

(where $\frac{V_m}{\frac{1}{\omega C}} = I_m$)

Derivation for Power.

$P = V \times I$

$V = V_m \sin(\omega t)$ & $I = I_m \sin\omega t$

$\therefore P = V_m \sin(\omega t) \cdot I_m \sin(\omega t + \frac{\pi}{2})$

$P = V_m I_m \sin(\omega t) \cdot \cos\omega t$

where $\sin(\omega t + \frac{\pi}{2})$

$P = V_m I_m \frac{\sin(2\omega t)}{2}$

$\sin\omega t \cdot \cos(2\omega t)$

$$\boxed{P = \frac{V_m I_m}{2} \sin(2\omega t)}$$

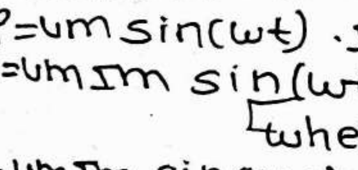
Active, reactive, apparent Power

1) Active:- $\boxed{P = VI\cos\phi}$

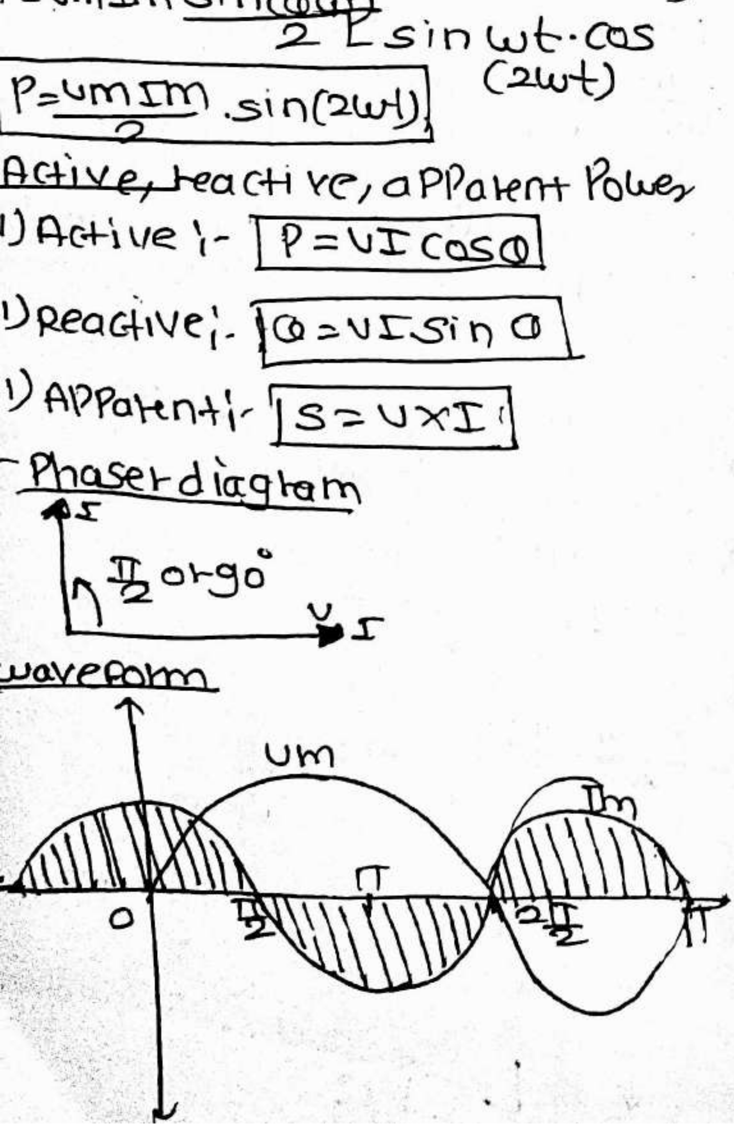
1) Reactive:- $\boxed{Q = VI\sin\phi}$

1) Apparent:- $\boxed{S = V \times I}$

Phaser diagram

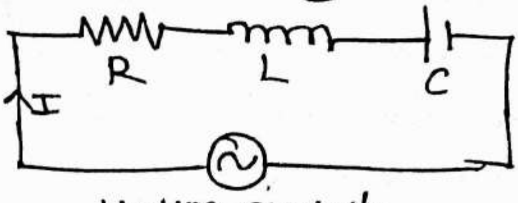


waveform



Series resonace:-

consider the series R-L-C circuit as show in fig. ①



$V = V_m \sin\omega t$.

The impedance of circuit is given by

$$\therefore \bar{Z} = R + jX_L - jX_C$$

$$\bar{Z} = R + j\omega L - j\frac{1}{\omega C}$$

$$\bar{Z} = R + j\left[\omega L - \frac{1}{\omega C}\right]$$

At resonace $Z = R$ i.e resisitive

There fore the condition for

$$\omega L - \frac{1}{\omega C} = 0$$

$$\omega_0^2 LC - 1 = 0$$

$$\omega_0^2 = \frac{1}{LC} \rightarrow \boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$$

$$2\pi f_0 = \frac{1}{\sqrt{LC}}$$

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}}}$$

where

f_0 = Resonant frequency of the ckt

Power factor:-

$$\therefore \cos\phi = \frac{R}{R_1} = 1$$

$$\boxed{\cos\phi = 1}$$

current:-

$$I_0 = \frac{V}{Z} = \frac{V}{R}$$

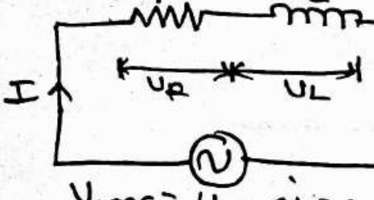
voltage:-

At Resonace $\omega_0 L = \frac{1}{\omega_0 C}$

$$\omega_0 L I_0 = \frac{1}{\omega_0 C} I_0$$

$$\boxed{V_{L0} = V_{C0}}$$

Series R-L circuit.



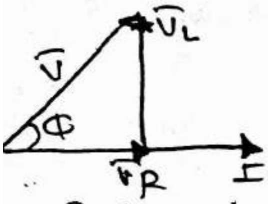
$V_{rms} = V_m \sin \omega t$.

let, V_{rms} & I_{rms} - be the rms value of applied Vtg & current.

∴ Potential diff across R $= V_R = R \cdot I$

∴ Potential diff across L $= V_L = X_L \cdot I$

∴ The $\bar{V}_R$ in phase with (I) whereas the vtg $\bar{V}_L$ leads the current I by 90°



$$\boxed{\cos\phi = \frac{V_R}{V}}$$

Impedence:-

$$\bar{V} = \bar{V}_R + \bar{V}_L$$
$$= R\bar{I} + jX_L\bar{I}$$
$$\bar{V} = \bar{I}(R + jX_L)$$
$$\Rightarrow \boxed{\frac{\bar{V}}{\bar{I}} = R + jX_L = \bar{Z}}$$

$\bar{Z} = Z\angle\phi$ — where $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega^2 L^2}$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

current:-

If the applied Vtg is given by

$V = V_m \sin \omega t$.

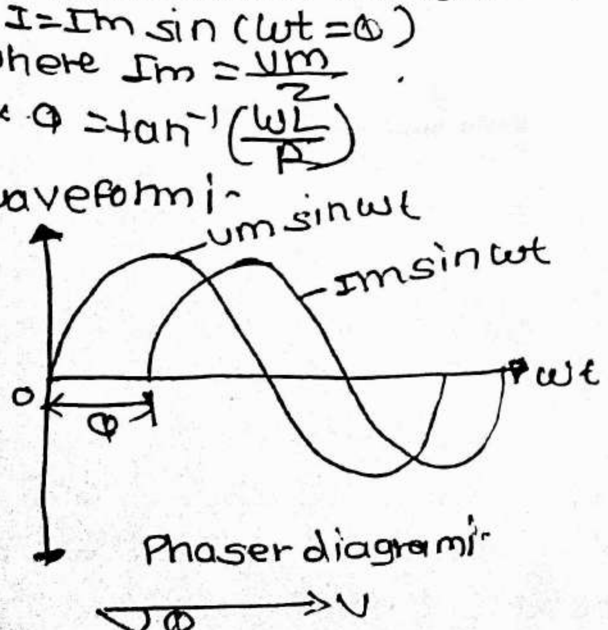
then the current eq^n will be,

$I = I_m \sin(\omega t - \phi)$

where $I_m = \frac{V_m}{Z}$

& $\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$

waveform:-



Phaser diagram:-

Power:-

(a) Instaneous Power.

$$P = V \cdot I$$
$$= V_m \sin \omega t \cdot I_m \sin(\omega t - \phi)$$
$$= V_m I_m \sin \omega t \cdot \sin(\omega t - \phi)$$
$$P = V_m I_m \frac{1}{2}\{\cos\phi - \cos(2\omega t - \phi)\}$$
$$\boxed{P = \frac{V_m I_m}{2}\cos\phi - \frac{V_m I_m}{2}\cos(2\omega t)}$$

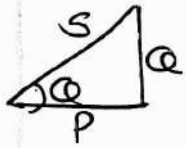
(b) average Power.

$$P_{avg} = \frac{V_m I_m}{2}\cos\phi$$
$$P_{avg} = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\cos\phi$$
$$\boxed{P_{avg} = V_{rms} I_{rms} \cos\phi} \text{ — } (*)$$

Power triangle:-

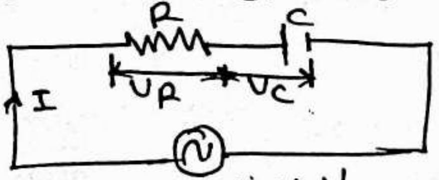
In term of circuit components

$\cos\phi = R/Z$



$$\boxed{\cos\phi = \frac{P}{S}}$$

Series R-C circuit.



$V = V_m \sin\omega t$

let V_{rms} & I_{rms} be the rms value of applied vtg & cdn to a respectively.

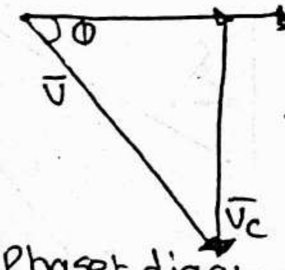
$\therefore$ Potential diff across R $= V_R = RI$

$\therefore$ Potential diff across C $= V_C = X_C I$

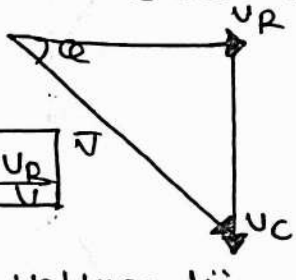
$\therefore$ The voltage V_R in phase with (I) where $\bar{V}_C$ lag behind the (I) by 90° $\therefore \bar{V} = \bar{V}_R + \bar{V}_C$

Phaser diag:-

The current (I) flow through the R & C so, that I is take as the



$\boxed{\cos\phi = \frac{V_R}{V}}$



Phaser diagram Voltage ~~triang~~

Impedence:-

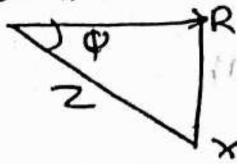
$$\bar{V} = \bar{V}_R + \bar{V}_C$$
$$= R\bar{I} - jX_C\bar{I}$$
$$\bar{V} = \bar{I}(R - jX_C)$$
$$\frac{\bar{V}}{\bar{I}} = R - jX_C = \bar{Z}$$
$$\therefore \bar{Z} = Z\angle -\phi$$
$$\therefore Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$$

and $\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$

$$\phi = \tan^{-1}\left(\frac{1}{\omega CR}\right)$$

where, $\bar{Z}$ is called complex impedance of series R-C

Impedence triangle



$\boxed{\cos\phi = \frac{R}{Z}}$

X_C Impedence triangle

Current:-

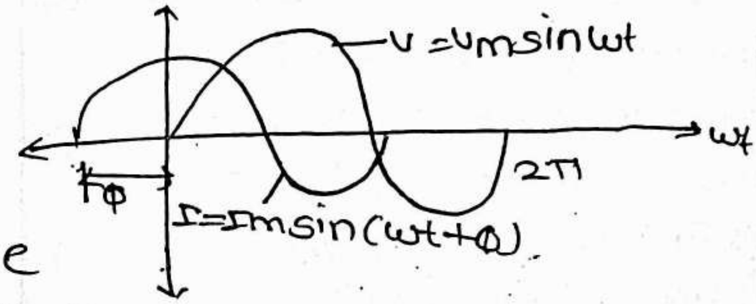
If the applied voltage is a given by $V = V_m \sin\omega t$.

$$I = I_m \sin(\omega t + \phi)$$

where $I_m = \frac{V_m}{Z}$

$$\therefore \phi = \tan^{-1}\left(\frac{X_C}{R}\right) = \tan^{-1}\left(\frac{1}{\omega CR}\right)$$

waveform:-



Power:-

Active:- $VI\cos\phi = I^2 R$

Reactive:- $VI\sin\phi = I^2 X_C$

Apparent:- $VI = I^2 Z$

Power triangle:-

Power factor:-

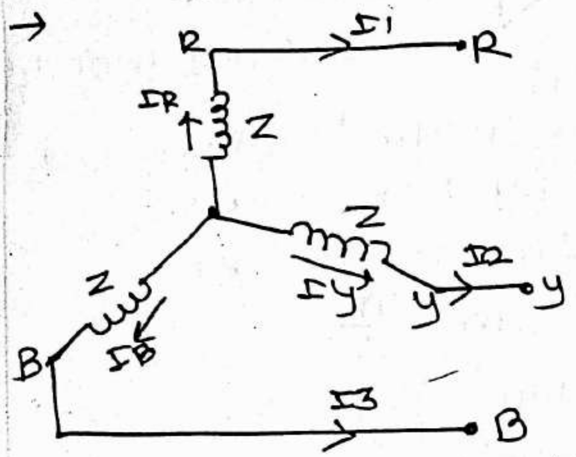
volt triangle $PF = \frac{V_R}{V}$

Impedence tri:- $PF = \frac{R}{Z}$

Power triangle:- $PF = \frac{P}{S}$

In case of an RC series ckt the Power factor is leating in nature.

relation between line and Phase value of current and voltage for balance 3-Phase - **Star** connection
→



Line voltage - $V_L = V_{RY} = V_{YB} = V_{BR}$
Line current - $I_L = I_R = I_y = I_B$
Phase voltage - $V_{ph} = V_{RY} = V_{YN} = V_{BN}$
Phase current - $I_{ph} = I_R = I_Y = I_B$

As Path for line current I_L and Phase current I_{ph} is same

$\boxed{I_L = I_{PH}}$

$\bar{V}_{RY} = \bar{V}_{RN} + \bar{V}_{NY}$

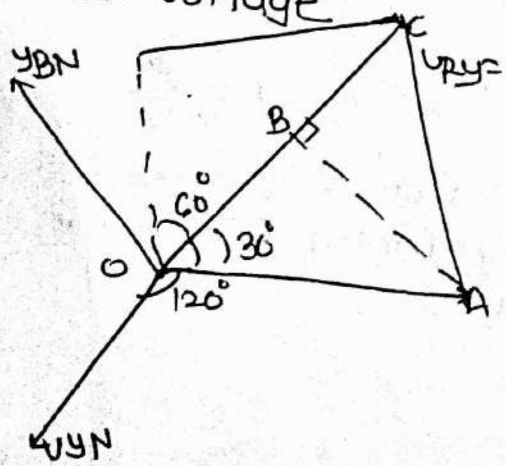
$\bar{V}_{NY} = -\bar{V}_{YN}$

$\bar{V}_{RY} = \bar{V}_{RN} - \bar{V}_{YN}$ — (I)

$\bar{V}_{YB} = \bar{V}_{YN} - \bar{V}_{BN}$ — (II)

$\bar{V}_{BY} = \bar{V}_{BN} - \bar{V}_{RN}$ — (III)

The Phase diagram will give a relation betn line voltage and Phaser voltage



Phaser diagram for the resitive load.

Angle betwn V_{RN} & $-V_{YN}$ is 60°
so $\angle AOB = 30°$

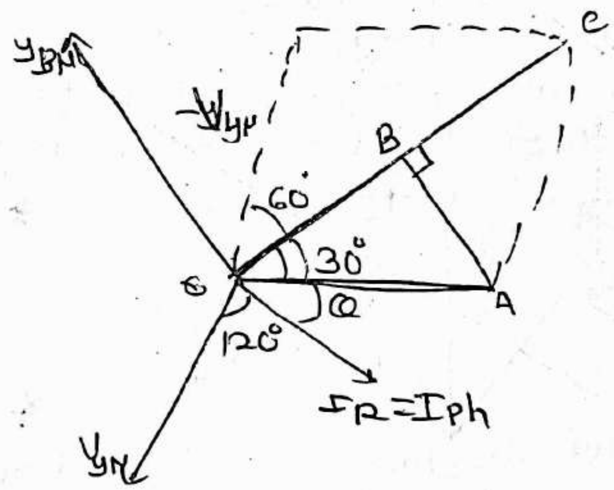
from $\triangle AOB$ $\cos 30 = \frac{OB}{OA} = \frac{2}{V_{RN}}$

$\frac{\sqrt{3}}{2} = \frac{\frac{V_L}{2}}{V_{ph}}$

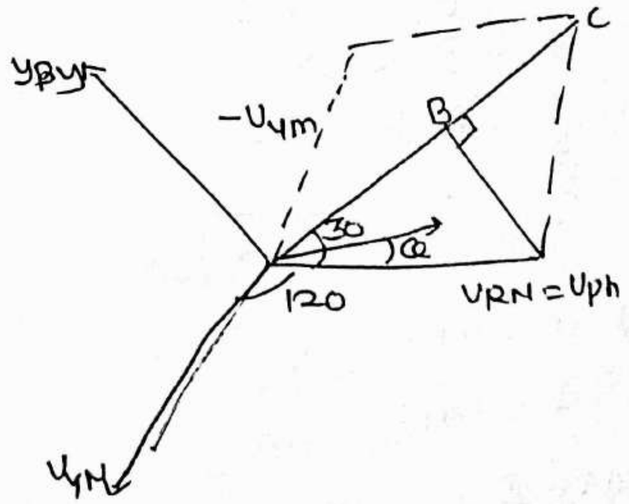
$\boxed{V_L = \sqrt{3} V_{Ph}}$

Thus line voltage is $\sqrt{3}$ time the Phaser voltage & line current & Phaser current are same.

Phaser dia for Inductive load



Phaser dia. for capaPacitive load



① Work Power energy

1] With usual notation derive the expression, $a_2 = \frac{a_1}{(1+a_1(t_2-t_1)}$

→ Let us consider a conducting material whose initial resistan is R_1 at temperature $t_1°c$ i.e at Point A.

The expression for R_2,

$$R_2 = R_1[1+a_1 \cdot (t_2-t_1)] \text{ — (I)}$$

where a_1 is T.C.R at $t_1°c$

The expression for R_1

$$R_1 = R_2[1+a_2 \cdot (t_1-t_2)] \text{ — (II)}$$

where a_2 is T.C.R at $t_2°c$

From ea^n ① & ② taking ratio

$$\frac{R_1}{R_2} = 1+a_2(t_2-t_1) \text{ — (III)}$$

$$= \frac{1}{1+a_1(t_2-t_1)} \text{ — (IV)}$$

From equation (III) & (IV)

$$a_2(t_2-t_1) = \frac{1}{1+a_1(t_2-t_1)} - 1$$

$$= \frac{1-1-a(t_2-t_1)}{1+a_1(t_2-t_1)} = \frac{-a_1(t_2-t_1)}{1+a_1(t_2-t_1)}$$

multiplying both side

$$a_2(t_2-t_1) = \frac{a_1(t_2-t_1)}{1+a_2(t_2-t_1)}$$

$$a_2 = \frac{a_1}{1+a_1(t_2-t_1)} \text{ — (V)}$$

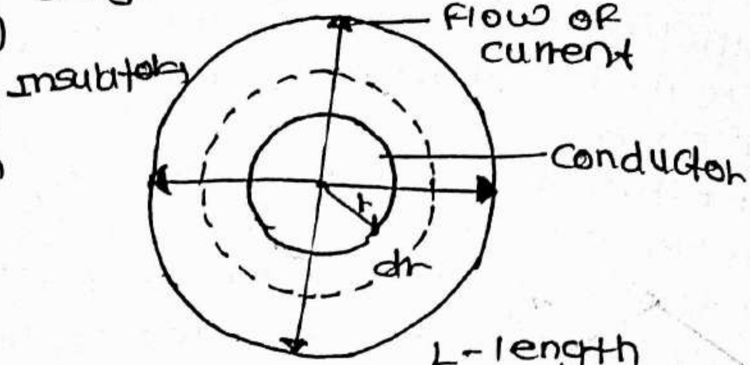
If we consider.

$$a_1 = \frac{a_0}{1+a_0 t}$$

form equation (V)

$$\boxed{a_1 - a_2 = a_1 a_2 (t_2-t_1)}$$

2) derive the expression for the insulation resistance of the single core cable.



L - length
P - Resistivity
R - Resistance
a - cross area

$$\boxed{R = \frac{PL}{a}} \text{ — (I)}$$

$$dR_i = \frac{P\,dr}{2\pi r l}$$

$$\therefore R_i = \int_{R_1}^{R_2} dR_i \text{ — (II)}$$

Put equation in ① & (II)

$$\therefore R_i = \int_{R_1}^{R_2} \frac{P\,dr}{2\pi r l}$$

$$R_i = \frac{P}{2\pi l} \int_{R_1}^{R_2} \frac{dr}{r}$$

$$R_i = \frac{P}{2\pi l} [\log r]_{R_1}^{R_2}$$

$$R_i = [\log_e R_2 - \log_e R_1]$$

where there! -

$$R_i = [\log_e R_2 - \log_e R_1]$$

$$\boxed{R_i = \frac{P}{2\pi l} \log_e \left[\frac{R_2}{R_1}\right]}$$

where:-

P = Density

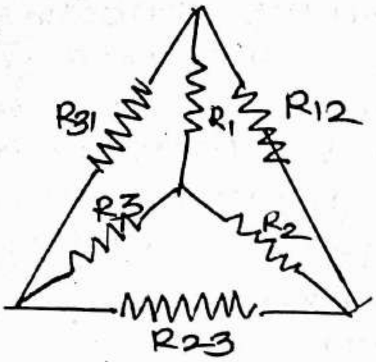
l = length

R_1 = radius of conductor

R_2 = radius of conductor + insulator

3) derive the expression for the conversion of a delta connected into an equivalent star circuit

→



Resistance betⁿ terminal 1 & 2

for delta :- $= \dfrac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}}$ — ①

for star $= R_1+R_2$ — ②

equating ① and ②

$\dfrac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} = R_1+R_2$ — ③

Similarly for resistance 3 and 1

$\dfrac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} = R_1+R_3$ — ④

Also for resistance 2 and 3

$\dfrac{R_{23}(R_{31}+R_{12})}{R_{12}+R_{23}+R_{31}} = R_2+R_3$ — ⑤

let find R_1, R_2, R_3 in term of R_{12}, R_{23}, R_{31} sub eaⁿ ④ & 5

$\dfrac{R_{23}(R_{31}+R_{12})-R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} = R_2-R_1$ — ⑥

Add eaⁿ ③ & ⑥

$\therefore \dfrac{2R_{12}\cdot R_{23}}{R_{12}+R_{23}+R_{31}} = 2R_2$

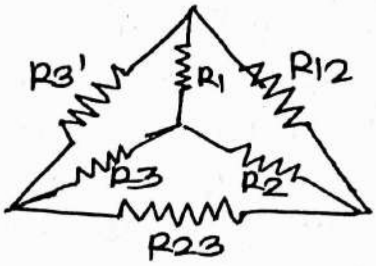
$\therefore R_2 = \dfrac{R_{12}R_{23}}{R_{12}+R_{23}+R_{31}}$

similarly, $R_1 = \dfrac{R_{12}\cdot R_{31}}{R_{12}+R_{23}+R_{31}}$

and $R_3 = \dfrac{R_{23}\cdot R_{31}}{R_{12}+R_{23}+R_{31}}$

4) derive the expression for the conversion of star connected in an delta connec

→



The Resistance betⁿ terminals R_1, R_2 & R_3

$R_1 = \dfrac{R_{12}\cdot R_{31}}{R_{12}+R_{23}+R_{31}}$ — (i)

$R_2 = \dfrac{R_{12}\cdot R_{23}}{R_{12}+R_{23}+R_{31}}$ — (ii)

$R_3 = \dfrac{R_{23}\cdot R_{31}}{R_{12}+R_{23}+R_{31}}$ — (iii)

multiply eaⁿ (i) & (ii)

$R_1 \cdot R_2 = \dfrac{R_{12}(R_{23}\cdot R_{31})}{R_{12}+R_{23}+R_{31}}$ — (iv)

$R_2 \cdot R_3 = \dfrac{R_{23}(R_{12}\cdot R_{31})}{R_{12}+R_{23}+R_{31}}$ — (v)

$R_1 \cdot R_3 = \dfrac{R_{31}(R_{12}\cdot R_{23})}{R_{12}+R_{23}+R_{31}}$ — (vi)

Add eaⁿ ④ ⑤ & ⑥

$R_1R_2 + R_2R_3 + R_1\cdot R_3$

$= \dfrac{(R_{12}^2 R_{23} R_{31} + R_{23}^2 R_{12} R_{23} R_{31} +)}{[R_{12}+R_{23}+R_{31}]}$

Taking common

$= \dfrac{R_{12} R_{23} R_{31}}{[R_{12}+R_{23}+R_{31}]}$

$R_1R_2 + R_2R_3 = R_1R_{23}$

$R_{23} = \dfrac{R_2 + R_2R_3 + R_3}{R_1}$

$\left[R_{23} = R_2+R_3 + \dfrac{R_2R_3}{R_1}\right]$ similarly

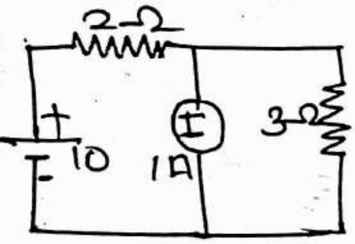
$\left[R_{12} = R_1+R_2 + \dfrac{R_1R_2}{R_3}\right]$

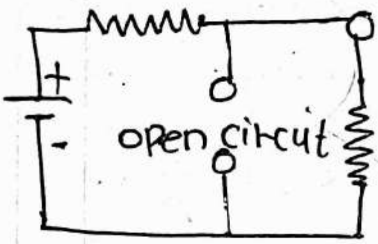
$\left[R_{31} = R_3+R_1 + \dfrac{R_3R_1}{R_2}\right]$

derive the theoram for the a superposition theoram.

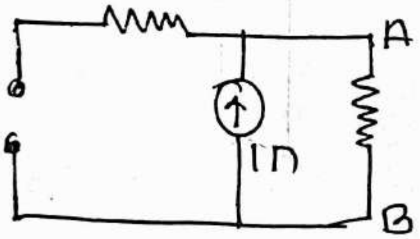
Statement :- In any linear bilatern network ion the connecting two or more energy source on the voltage across an a current to through any element is an the alebralic sumation of the voltag or current to procedulted by on the induvaual source on to acting alon.

- while the source are two o replaced by their internal resistance.





Start circuit



$R_T = 2+3 = 5\Omega$

current $(I') = \dfrac{\text{Total voltage}}{\text{Total resistance}}$

$I' = \dfrac{10}{5}$

$\boxed{I' = 2A\downarrow}$

formula :-

current in any branch

$= \dfrac{\text{supply current} \times \text{open branch}}{\text{Addition of resistance}}$

$I'' = \dfrac{1\times 2}{2+3}$

$= \dfrac{2}{5}$

$\boxed{I'' = 0.4A\downarrow}$

• kirchhoff current law (KCL)

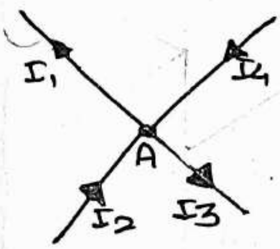
Statement :- Algebric sum of the current meeting at any the junction point in an electric circuit is alway zero

$\Sigma I = 0$

In other word at any junction or node is an electric the circuit. sum of incoming a current is eauca to sum of outgoing current.

i.e any node $\Sigma IC = \Sigma OC$

Explanation :- consider a node as show in fig.



four branch meet at junction or node

$I_2 + I_4 = I_1 + I_3$

• kirchhoff voltage law (KVL)

statement :- In any electrical network, algebric sum of V drop across various element around any closed loop

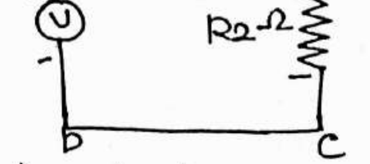
$\Sigma IR = \Sigma E$

In other word. if we trace any closed path or loop in an that electrical network an algebric sum of branch voltage is alway zero

$\Sigma V = 0$

explanation :-

consider a network show below



using KVL

$\Sigma V = 0$

$-IR_1 - IR_2 + V = 0 \quad V = I(R_1 + R_2)$

$I = (V/(R_1 + R_2))$